



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Indiana Standards Laboratory
2919 Shelby Street
Indianapolis, IN 46203-5236

Fulfills the requirements of

ISO/IEC 17025:2017

In the field of

CALIBRATION and DIMENSIONAL MEASUREMENT

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org.

A handwritten signature in black ink, appearing to read 'R. Douglas Leonard Jr.', is positioned above a horizontal line.

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 31 December 2024
Certificate Number: L2222



This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017.
This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory
quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

Indiana Standards Laboratory

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CALIBRATION AND DIMENSIONAL MEASUREMENT

Valid to: **December 31, 2024**

Certificate Number: **L2222**

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sound Level Calibrator	114 dB 125 Hz to 1 kHz	0.23 dB	GR 1562A Calibrator
	114 dB 2 kHz	0.34 dB	
	94 dB 250 Hz, 1 kHz	0.23 dB	B&K 2206 SL Meter GRAS 42AG Sound Calibrator Agilent 34411A DMM
Sound Level Meters ^[1] Sound Level	114 dB 125 Hz to 1 kHz	0.25 dB	GR 1562A Calibrator
	114 dB 2 kHz	0.33 dB	
	94 dB 250 Hz, 1 kHz	0.26 dB	GRAS 42AG Sound Calibrator
Sound Level Meters ^[1] Linearity	(0 to 120) dB 1 kHz	0.063 dB	Ratio Transformer Agilent 3458A DMM

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters ^[1]	(4, 7, 10) pH	0.02 pH	Standard pH Buffers Thermometer 0.1 °C

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Conductivity Meters ^[1]	10 μ S/cm	0.57 μ S/cm	Standard Solutions
	100 μ S/cm	2.3 μ S/cm	
	1 000 μ S/cm	5.6 μ S/cm	
	10 000 μ S/cm	49 μ S/cm	
	100 000 μ S/cm	450 μ S/cm	
1 412 μ S/cm	5.5 μ S/cm		
Refractive Index Brix	(0.1 to 20) Brix	0.2 % of reading	Scale Sugar Distilled Water

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance (Source)	(0.1 to 1) pF	0.000 2 pF + 45 μ F/F	GR 1422-CD Capacitor GR 1615A Bridge
	(1 to 10) pF	0.001 4 pF + 50 μ F/F	
	(10 to 100) pF	0.000 78 pF + 10 μ F/F	GR 1422-CL Capacitor GR 1615A Bridge
	(100 to 1 000) pF	0.003 6 pF + 23 μ F/F	GR-1422-CB Capacitor GR-1615A Bridge
	(1 to 10) nF	0.000 004 2 nF + 17 μ F/F	GR 1423A Capacitor GR 1615A Bridge
	(10 to 100) nF	0.000 14 nF + 29 μ F/F	
(100 to 1 000) nF	0.000 13 nF + 37 μ F/F		
Capacitance (Measure)	(1 to 10) μ F	220 μ F/F	ISL Polaris Capacitance Decade GR 1615A Bridge
	(10 to 100) μ F	530 μ F/F	
Capacitance (Measure)	(0.1 to 1) pF	0.000 03 pF + 60 μ F/F	GR1615A Bridge GR 1403-K Capacitor
	(1 to 10) pF	0.000 051 pF + 16 μ F/F	GR 1615A Bridge GR 1403-G Capacitor
	(10 to 100) pF	0.000 076 pF + 7.2 μ F/F	GR 1615A Bridge GR 1404-B Capacitor
	(100 to 1 000) pF	0.000 21 pF + 7.7 μ F/F	
	(1 to 10) nF	0.000 001 9 nF + 11 μ F/F	
(10 to 100) nF	0.000 1 nF + 21 μ F/F	GR 1615A Bridge GR 1615-P1 Bridge	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance (Measure)	(100 to 1 000) nF	0.000 41 nF + 27 μ F/F	GR 1615A Bridge, GR 1409-T Capacitor
	(1 to 10) μ F	0.000 008 6 μ F + 210 μ F/F	GR 1615A Bridge
	(10 to 100) μ F	-0.000 014 μ F + 530 μ F/F	GR 1689M RLC Bridge
AC Current (Source) ^[1]	(0.1 to 1) mA	160 μ A/A + 0.3 nA	GR 1440 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
	(10 to < 50) Hz		
	(0.1 to 1) mA	88 μ A/A	
	(0.05 to 1) kHz		
	(0.1 to 1) mA	100 μ A/A + 0.5 nA	
	(> 1 to 5) kHz		
	(0.1 to 1) mA	240 μ A/A + 3.1 nA	
	(>5 to 10) kHz		
	(>1 to 10) mA	150 μ A/A + 1.5 nA	
	(10 to <50) Hz		
	(>1 to 10) mA	84 μ A/A + 1.2 nA	
(0.05 to 1) kHz			
(>1 to 10) mA	83 μ A/A + 10 nA		
(>1 to 5) kHz			
(>1 to 10) mA	90 μ A/A + 74 nA		
(>5 to 10) kHz			
AC Current (Source) ^[1]	(>10 to 100) mA	150 μ A/A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
	(10 to <50) Hz		
	(>10 to 100) mA	90 μ A/A	
	(0.05 to 1) kHz		
	(>10 to 100) mA	96 μ A/A + 22 nA)	
	(>1 to 5) kHz		
	(>10 to 100) mA	110 μ A/A + 36 n	
	(>5 to 10) kHz		
	(>0.1 to 1) A	150 μ A/A	
	(10 to <50) Hz		
	(>0.1 to 1) A	91 μ A/A	
	(0.05 to 1) kHz		
	(>0.1 to 1) A	100 μ A/A – 0.74 μ A	
(>1 to 5) kHz			
(>0.1 to 1) A	160 μ A/A + 5 μ A		
(>5 to 10) kHz			
(>1 to 10) A	160 μ A/A		
(10 to <50) Hz			

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current (Source) ^[1]	(>1 to 10) A (0.05 to 1) kHz	96 μ A/A – 2.2 μ A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
AC Current (Source) ^[1]	(>1 to 10) A (>1 to 5) kHz	150 μ A/A – 49 μ A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
AC Current (Source) ^[1]	(>10 to 20) A (10 to <50) Hz (>10 to 20) A (0.05 to 1) kHz (>10 to 20) A (>1 to 5) kHz	150 μ A/A + 110 μ A 100 μ A/A 160 μ A/A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
AC Current (Measure) ^[1]	(0.1 to 1) mA (10 to <50) Hz (0.1 to 1) mA (0.05 to 1) kHz (0.1 to 1) mA (>1 to 5) kHz (0.1 to 1) mA (>5 to 10) kHz (>1 to 10) mA (10 to <50) Hz (>1 to 10) mA (0.05 to 1) kHz (>1 to 10) mA (>1 to 5) kHz (>1 to 10) mA (>5 to 10) kHz	160 μ A/A + 0.3 nA 88 μ A/A 100 μ A/A + 0.5 nA 240 μ A/A + 3.1 nA 150 μ A/A + 1.5 nA 84 μ A/A + 1.2 nA 83 μ A/A + 10 nA 90 μ A/A + 74 nA	GR 1440 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
AC Current (Measure) ^[1]	(>10 to 100) mA (10 to <50) Hz (>10 to 100) mA (0.05 to 1) kHz (>10 to 100) mA (>1 to 5) kHz (>10 to 100) mA (>5 to 10) kHz (>0.1 to 1) A (10 to <50) Hz	150 μ A/A 90 μ A/A 96 μ A/A + 22 nA 110 μ A/A + 36 nA 150 μ A/A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current (Measure) ^[1]	(>0.1 to 1) A (0.05 to 1) kHz	91 μ A/A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
	(>0.1 to 1) A (>1 to 5) kHz	100 μ A/A – 0.74 μ A	
AC Current (Measure) ^[1]	(>1 to 1) A (>5 to 10) kHz	160 μ A/A – 5 μ A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
AC Current (Measure) ^[1]	(>1 to 10) A (10 to <50) Hz	160 μ A/A	Holt CS1 Shunt Holt 6A Thermal Transfer Standard Agilent 3458A Multimeter
	(>1 to 10) A (0.05 to 1) kHz	96 μ A/A + 2.2 μ A	
	(>1 to 10) A (>1 to 5) kHz	150 μ A/A – 49 μ A	
	(>1 to 10) A (>5 to 10) kHz	260 μ A/A – 110 μ A	
	(>10 to 20) A (10 to <50) Hz	150 μ A/A + 110 μ A	
	(>10 to 20) A (0.05 to 1) kHz	100 μ A/A	
	(>10 to 20) A (>1 to 5) kHz	160 μ A/A	
	(>10 to 20) A (>5 to 10) kHz	250 μ A/A	
DC Current (Source & Measure) ^[1,3]	(0 to 1) nA	0.1 % reading + 160 fA	Monitored Multifunction Calibrator Agilent 3458A Multimeter Standard Resistor
	(>1 to 10) nA	55 μ A/A + 1.1 pA	
	(>10 to 100) nA	1.5 μ A/A + 5.8 pA	
	>100 nA to 1 μ A	0.4 μ A/A + 24 pA	
	(>1 to 10) μ A	1.2 μ A/A + 62 pA	
	(>10 to 100) μ A	1 μ A/A + 570 pA	
DC Current (Source & Measure) ^[1,3]	>100 μ A to 1 mA	1.1 μ A/A + 5.7 nA	Monitored Multifunction Calibrator Agilent 3458A Multimeter Standard Resistor
	(>1 to 10) mA	1 μ A/A + 57 nA	
	(>10 to 100) mA	1.1 μ A/A + 570 nA	
	>100 mA to 2 A	4.1 μ A/A + 5.5 μ A	Transconductance Amplifier Agilent 3458A Multimeter Standard Shunt
	(>2 to 10) A	22 μ A/A + 32 μ A	
	(>10 to 20) A	49 μ A/A - 14 μ A	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current (Source & Measure) ^[1,3]	(>20 to 100) A	67 μ A/A - 370 μ A	Power Supply Agilent 3458A Multimeter Standard Shunt
DC Current (Measure) ^[1,3]	(>100 to 1 000) A (>1 000 to 2 000) A	0.53 mA + 0.1 % of reading 0.13 % of reading + 32 mA	Agilent 3458A Multimeter Standard Shunt
DC Current (Simulated Source) ^[1]	(20 to 40) ADC (40 to 200) ADC (200 to 1 000) ADC	0.04 A + 0.39 % of reading 0.037 A + 0.48 % of reading 0.31 A + 0.32 % of reading	Transconductance Amplifier Current Coil
Inductance (Source)	100 μ H @ 1 kHz	0.08 % of nominal	General Radio 1482-B Inductor
	1 mH @ 1 kHz	0.02 % of nominal	General Radio 1482-E Inductor
	10 mH @ 100 Hz 10 mH @ 1 kHz	0.07 % of nominal 0.02 % of nominal	General Radio 1482-H Inductor
	100 mH @ 100 Hz 100 mH @ 1 kHz	0.08 % of nominal 0.02 % of nominal	General Radio 1482-L Inductor
	1 H @ 100 Hz 1 H @ 1 kHz	0.07 % of nominal 0.02 % of nominal	General Radio 1482-P Inductor
	10 H @ 100 Hz 10 H @ 1 kHz	0.07 % of nominal 0.02 % of nominal	General Radio 1482-T Inductor
Inductance (Measure)	100 μ H @ 1 kHz 1 mH @ 1 kHz 10 mH @ 100 Hz 10 mH @ 1 kHz 100 mH @ 100 Hz 100 mH @ 1 kHz 1 H @ 100 Hz 1 H @ 1 kHz 10 H @ 100 Hz 10 H @ 1 kHz	0.1 % of reading 0.03 % of reading 0.09 % of reading 0.03 % of reading 0.09 % of reading 0.03 % of reading 0.08 % of reading 0.03 % of reading 0.09 % of reading 0.03 % of reading	General Radio 1689 RLC Bridge
Magnetometers / Flux Meters	(0 to 20) G (20 to 200) G (200 to 2 000) G (2 000 to 20 000) G	0.014 G + 1.2 % of reading 0.19 G + 1.2 % of reading 1.6 G + 0.82 % of reading 19 G + 0.73 % of reading	Gauss Meter With Transverse Probe Helmholtz Coil
Resistance Fixed Point (Source) ^[1]	100 μ Ω 1 m Ω 10 m Ω 100 m Ω	4.2 μ Ω / Ω 2.8 μ Ω / Ω 2.2 μ Ω / Ω 1.8 μ Ω / Ω	Otto Wolff 0.0001 Resistor Guildline 9975 Comparator Guildline 9923 Extender 1 Ω Standard

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance Fixed Point (Source) ^[1]	1 Ω	1.6 μΩ/Ω	Guildline 9975 Comparator 1 Ω Standard
	10 Ω 100 Ω 1 kΩ	1.2 μΩ/Ω 1.4 μΩ/Ω 1.2 μΩ/Ω	Guildline 9975 Comparator 100 Ω Standard
	10 kΩ	1.7 μΩ/Ω	Guildline 9975 Comparator 1 kΩ Standard
	100 kΩ	2.3 μΩ/Ω	Guildline 9975 Comparator 10 kΩ Standard
	1 MΩ	3.3 μΩ/Ω	Guildline 9975 Comparator 100 kΩ Standard
	10 MΩ	4.6 μΩ/Ω	Agilent 3458A Multimeter 1 MΩ Standard 1 MΩ per step Decade
	100 MΩ	19 μΩ/Ω	Agilent 3458A Multimeter 10 MΩ Standard 10 MΩ per step Decade
	1 GΩ	110 μΩ/Ω	1 GΩ Fixed Point Source Agilent 3458A Multimeter 100 MΩ Standard 100 MΩ per step Decade
	10 GΩ	0.085 % of reading	Leeds Northrup 4232B Bridge 1 GΩ Standard 1 GΩ per step Decade
	100 GΩ	0.21 % of reading	Wavetek 4800A Multifunction Calibrator Agilent 3458A Multimeter 100 GΩ Standard 1 MΩ Standard
	Resistance Ranges (Source) ^[1]	100 μΩ to 1 mΩ	70 μΩ/Ω
(1 to 10) mΩ		-0.002 μΩ + 5.6 μΩ/Ω	Guildline 9975A Comparator Leeds & Northrup 4300 Milliohm Standard



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance Ranges (Source) ^[1]	(10 to 100) mΩ	2.3 μΩ + 28 μΩ/Ω	ESI RS925D Decade Resistor Leeds & Northrup 4222-B Resistor Agilent 3458A Multimeter
	100 mΩ to 1 Ω	1.1 μΩ + 14 μΩ/Ω	ESI RS925D Decade Resistor Leeds & Northrup 4020-B Resistor Agilent 3458A Multimeter
	(1 to 10) Ω	9.9 μΩ + 2.3 μΩ/Ω	ESI RS925A Decade Resistor Agilent 3458A Multimeter 10 Ω Fixed Point
	(10 to 100) Ω	90 μΩ + 1.7 μΩ/Ω	ESI RS925A Decade Resistor Agilent 3458A Multimeter 100 Ω Fixed Point
	100 Ω to 1 kΩ	44 μΩ + 2.1 μΩ/Ω	ESI RS925A Decade Resistor Agilent 3458A Multimeter 1 kΩ Fixed Point
	(1 to 10) kΩ	350 μΩ + 2.5 μΩ/Ω	ESI RS925A Decade Resistor Agilent 3458A Multimeter 10 kΩ Fixed Point
	(10 to 100) kΩ	3 mΩ + 2.9 μΩ/Ω	ESI RS925A Decade Resistor Agilent 3458A Multimeter 100 kΩ Fixed Point
	100 kΩ to 1 MΩ	140 mΩ + 3.9 μΩ/Ω	ESI RS925A Decade Resistor Agilent 3458A Multimeter 1MΩ Fixed Point
	(1 to 10) MΩ (10 to 100) MΩ	6.8 Ω + 7 μΩ/Ω 250 Ω + 59 μΩ/Ω	Agilent 3458A Multimeter PPM-R3-1111 Decade Resistor 1 MΩ Fixed Point

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance Ranges (Source) ^[1]	100 MΩ to 1 GΩ	-0.014 Ω + 290 μΩ/Ω	PPM-R3-1111 Decade Resistor Leeds & Northrup 4232B Bridge
Resistance Fixed Point (Measure) ^[1]	100 μΩ 1 m Ω 10 mΩ 100 mΩ	4.2 μΩ/Ω 2.8 μΩ/Ω 2.2 μΩ/Ω 1.8 μΩ/Ω	Otto Wolff 0.0001 Resistor Guildline 9975 Comparator Guildline 9923 Extender 1 Ω Standard
	1 Ω	1.6 μΩ/Ω	Guildline 9975 Comparator 1 Ω Standard
	10 Ω 100 Ω 1 kΩ	1.2 μΩ/Ω 1.4 μΩ/Ω 1.2 μΩ/Ω	Guildline 9975 Comparator 100 Ω Standard
	10 kΩ	1.7 μΩ/Ω	Guildline 9975 Comparator 1 kΩ Standard
	100 kΩ	2.3 μΩ/Ω	Guildline 9975 Comparator 10 kΩ Standard
	1 MΩ	3.3 μΩ/Ω	Guildline 9975 Comparator 100 kΩ Standard
	10 MΩ	7.5 μΩ/Ω	Agilent 3458A Multimeter 10 MΩ Fixed Point Reference
	100 MΩ	61 μΩ/Ω	Agilent 3458A Multimeter 100 MΩ Fixed Point Reference Decade
	1 GΩ	390 μΩ/Ω	Agilent 3458A Multimeter 1 GΩ Fixed Point Reference Decade
	10 GΩ	0.1 % of reading	Certified Leeds Northrup 4232B Bridge 10 GΩ Fixed Point Reference
	100 GΩ	0.21 % of reading	Wavetek 4800A Multifunction Calibrator Agilent 3458A Multimeter 100 GΩ Standard 1 MΩ Standard
	Resistance Ranges (Measure) ^[1]	(50 to 100) μΩ 100 μΩ to 1 mΩ	0.006 μΩ – 60.4 μΩ/Ω 6.3 μΩ/Ω

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance Ranges and Fixed Points (Measure) ^[1]	(1 to 10) mΩ	-0.002 μΩ + 5.6 μΩ/Ω	Guidline 9975A Comparator Leeds & Northrup 4300 Milliohm Standard
	(10 to 100) mΩ	0.029 μΩ + 5.8 μΩ/Ω	Guidline 9975 Comparator /9923 Extender
	100 mΩ to 1 Ω (1 to 10) Ω	1.1 μΩ + 14 μΩ/Ω 9.9 μΩ + 2.3 μΩ/Ω	Agilent 3458A Multimeter 1 Ω Fixed Point
	(10 to 100) Ω	90 μΩ + 1.7 μΩ/Ω	ESI RS925D Decade Resistor Agilent 3458A Multimeter 100 Ω Fixed Point
	100 Ω to 1 kΩ	44 μΩ + 2.1 μΩ/Ω	ESI RS925D Decade Resistor Agilent 3458A Multimeter 1 kΩ Fixed Point
	(1 to 10) kΩ	350 μΩ + 2.5 μΩ/Ω	ESI RS925D Decade Resistor Agilent 3458A Multimeter 10 kΩ Fixed Point
	(10 to 100) kΩ	3 mΩ + 2.9 μΩ/Ω	ESI RS925D Decade Resistor Agilent 3458A Multimeter 100 kΩ Fixed Point
	100 kΩ to 1 MΩ	140 mΩ + 3.9 μΩ/Ω	ESI RS925D Decade Resistor Agilent 3458A Multimeter 1 MΩ Fixed Point
	(1 to 10) MΩ	6.8 Ω + 7.0 μΩ/Ω	PPM R3-1111 Decade Resistor Agilent 3458A Multimeter 10 MΩ Fixed Point
	(10 to 100) MΩ	250 Ω + 59 μΩ/Ω	PPM R3-1111 Decade Resistor Agilent 3458A Multimeter 100 MΩ Fixed Point
Resistance Ranges (Measure) ^[1]	100 MΩ to 1 GΩ	-0.014 Ω + 290 μΩ/Ω	PPM R3-1111 Decade Resistor Leeds & Northrup 4232B Bridge

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Calibration of RTD Indicators ^[1]	(-200 to 0) °C (0 to 130) °C (130 to 600) °C (600 to 849) °C	0.01 °C 0.02 °C 0.12 °C 0.16 °C	Resistance Decade RTD Tables
AC Voltage (Source) ^[1]	1 mV 50 Hz to 1 kHz (>1 to 10) mV 50 Hz to 1 kHz (>10 to 100) mV 50 Hz to 1 kHz	0.25 % of reading 120 μV/V 46 μV/V	Ratio Transformer
AC Voltage (Source) ^[1]	(>10 to 100) mV 1 kHz to 20 kHz (>10 to 100) mV 20 kHz to 50 kHz (>10 to 100) mV 50 kHz to 100 kHz	0.012 mV + 0.000 32 mV/mV 0.012 mV + 0.000 88 mV/mV 0.014 mV + 0.000 87 mV/mV	Wavetek 4800 Multifunction Calibrator
AC Voltage (Source) ^[1]	(0.25 V to 0.5) V 10 Hz (0.25 to 0.5) V 20 Hz (0.25 to 0.5) V 50 Hz to 50 kHz (0.25 to 0.5) V 50 kHz to 100 kHz (0.25 to 0.5) V 100 kHz to 500 kHz (0.25 to 0.5) V 500 kHz to 1 MHz (>0.5 to 1) V 10 Hz (>0.5 to 1) V 20 Hz (>0.5 to 1) V 50 Hz to 1 kHz (>0.5 to 1) V 1 kHz to 10 kHz (>0.5 to 1) V 10 kHz to 50 kHz (>0.5 to 1) V 50 kHz to 100 kHz	150 μV/V 70 μV/V 65 μV/V 70 μV/V 225 μV/V 750 μV/V 135 μV/V 65 μV/V 55 μV/V 45 μV/V 40 μV/V 50 μV/V	Wavetek 4800A Multifunction Calibrator Holt 6A Thermal Transfer Standard

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage (Source) ^[1]	(>0.5 to 1) V 100 kHz to 500 kHz	150 μ V/V	Wavetek 4800A Multifunction Calibrator Holt 6A Thermal Transfer Standard
	(>0.5 to 1) V 500 kHz to 1 MHz	625 μ V/V	
	(>1 to 10) V 10 Hz	125 μ V/V	
	(>1 to 10) V 20 Hz	50 μ V/V	
	(>1 to 10) V 50 Hz to 20 kHz	30 μ V/V	
	(>1 to 10) V 20 kHz to 50 kHz	40 μ V/V	
	(>1 to 10) V 50 kHz to 100 kHz	50 μ V/V	
	(>1 to 10) V 100 kHz to 500 kHz	150 μ V/V	
	(>1 to 10) V 500 kHz to 1 MHz	625 μ V/V	
	(>10 to 50) V 10 Hz	125 μ V/V	
	(>10 to 50) V 20 Hz	50 μ V/V	
	(>10 to 50) V 50 Hz to 20 kHz	30 μ V/V	
	(>10 to 50) V 20 Hz to 50 kHz	40 μ V/V	
	(>10 to 50) V 50 Hz to 100 kHz	50 μ V/V	
	(>10 to 50) V 100 Hz to 200 kHz	150 μ V/V	
	(>50 to 100) V 10 Hz	125 μ V/V	
	(>50 to 100) V 20 Hz	50 μ V/V	
	(>50 to 100) V 50 Hz to 20 kHz	30 μ V/V	
	(>50 to 100) V 20 kHz to 50 kHz	40 μ V/V	
	(>50 to 100) V 50 kHz to 100 kHz	50 μ V/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage (Source) ^[1]	(>100 to 150) V 10 Hz	125 μ V/V	Wavetek 4800A Multifunction Calibrator Holt 6A Thermal Transfer Standard
	(>100 to 150) V 20 Hz	50 μ V/V	
	(>100 to 150) V 50 Hz to 1 kHz	30 μ V/V	
	(>100 to 150) V 1 kHz to 10 kHz	40 μ V/V	
	(>100 to 150) V 10 kHz to 20 kHz	50 μ V/V	
	(>100 to 150) V 20 kHz to 50 kHz	65 μ V/V	
	(>100 to 150) V 50 kHz to 100 kHz	100 μ V/V	
	(>150 to 300) V 10 Hz	125 μ V/V	
	(>150 to 300) V 20 Hz	50 μ V/V	
	(>150 to 300) V 50 Hz to 1 kHz	30 μ V/V	
	(>150 to 300) V 1 kHz to 10 kHz	40 μ V/V	
	(>150 to 300) V 10 kHz to 20 kHz	50 μ V/V	
	(>150 to 300) V 20 kHz to 50 kHz	65 μ V/V	
	(>300 to 500) V 10 Hz	125 μ V/V	
	(>300 to 500) V 20 Hz	50 μ V/V	
	(>300 to 500) V 50 Hz to 1 kHz	35 μ V/V	
	(>300 to 500) V 1 kHz to 10 kHz	60 μ V/V	
	(>300 to 500) V 10 kHz to 20 kHz	90 μ V/V	
	(>300 to 500) V 20 kHz to 50 kHz	110 μ V/V	
	(>500 to 1 200) V 10 Hz	125 μ V/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage (Source) ^[1]	(>500 to 1 200) V 20 Hz	50 μ V/V	Wavetek 4800A Multifunction Calibrator Holt 6A Thermal Transfer Standard
	(>500 to 1 200) V 50 Hz to 1 kHz	40 μ V/V	
	(>500 to 1 200) V 1 kHz to 10 kHz	60 μ V/V	
	(>500 to 1 200) V 10 kHz to 20 kHz	120 μ V/V	
	(>500 to 1 200) V 20 kHz to 50 kHz	145 μ V/V	
AC Voltage (Measure) ^[1]	1 mV 50 Hz to 1 kHz	0.26 % of reading	Ratio Transformer
	(>1 to 10) mV 50 Hz to 1 kHz	120 μ V/V	
	(>10 to 100) mV 50 Hz to 1 kHz	49 μ V/V	
AC Voltage (Measure) ^[1]	(>10 to 100) mV 1 kHz to 20 kHz	0.002 3 mV + 0.000 17 mV/mV	Agilent 3458A Multimeter
	(>10 to 100) mV 20 kHz to 50 kHz	0.002 9 mV + 0.000 34 mV/mV	
	(>10 to 100) mV 50 kHz to 100 kHz	0.013 mV – 0.000 13 mV/mV	
AC Voltage (Measure) ^[1]	0.25 V to 0.5 V 10 Hz	150 μ V/V	Holt 6A Thermal Transfer Standard
	0.25 V to 0.5 V 20 Hz	70 μ V/V	
	(0.25 to 0.5) V 50 Hz to 50 kHz	65 μ V/V	
	(0.25 to 0.5) V 50 kHz to 100 kHz	70 μ V/V	
	(0.25 to 0.5) V 100 kHz to 500 kHz	225 μ V/V	
	(0.25 to 0.5) V 500 kHz to 1 MHz	750 μ V/V	
	(>0.5 to 1) V 10 Hz	135 μ V/V	
	(>0.5 to 1) V 20 Hz	65 μ V/V	
	(>0.5 to 1) V 50 Hz to 1 kHz	55 μ V/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage (Measure) ^[1]	(>0.5 to 1) V 1 kHz to 10 kHz	45 μ V/V	Holt 6A Thermal Transfer Standard
	(>0.5 to 1) V 10 kHz to 50 kHz	40 μ V/V	
	(>0.5 to 1) V 50 kHz to 100 kHz	50 μ V/V	
	(>0.5 to 1) V 100 kHz to 500 kHz	150 μ V/V	
	(>0.5 to 1) V 500 kHz to 1 MHz	625 μ V/V	
	(>1 to 10) V 10 Hz	125 μ V/V	
	(>1 to 10) V 20 Hz	50 μ V/V	
	(>1 to 10) V 50 Hz to 20 kHz	30 μ V/V	
	(>1 to 10) V 20 kHz to 50 kHz	40 μ V/V	
	(>1 to 10) V 50 kHz to 100 kHz	50 μ V/V	
	(>1 to 10) V 100 kHz to 500 kHz	150 μ V/V	
	(>1 to 10) V 500 kHz to 1 MHz	625 μ V/V	
	(>10 to 50) V 10 Hz	125 μ V/V	
	(>10 to 50) V 20 Hz	50 μ V/V	
	(>10 to 50) V 50 Hz to 20 kHz	30 μ V/V	
	(>10 to 50) V 20 Hz to 50 kHz	40 μ V/V	
	(>10 to 50) V 50 Hz to 100 kHz	50 μ V/V	
	(>10 to 50) V 100 Hz to 200 kHz	150 μ V/V	
	(>50 to 100) V 10 Hz	125 μ V/V	
	(>50 to 100) V 20 Hz	50 μ V/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage (Measure) ^[1]	(>50 to 100) V 50 Hz to 20 kHz	30 μ V/V	Holt 6A Thermal Transfer Standard
	(>50 to 100) V 20 kHz to 50 kHz	40 μ V/V	
	(>50 to 100) V 50 kHz to 100 kHz	50 μ V/V	
	(>100 to 150) V 10 Hz	125 μ V/V	
	(>100 to 150) V 20 Hz	50 μ V/V	
	(>100 to 150) V 50 Hz to 1 kHz	30 μ V/V	
	(>100 to 150) V 1 kHz to 10 kHz	40 μ V/V	
	(>100 to 150) V 10 kHz to 20 kHz	50 μ V/V	
	(>100 to 150) V 20 kHz to 50 kHz	65 μ V/V	
	(>100 to 150) V 50 kHz to 100 kHz	100 μ V/V	
	(>150 to 300) V 10 Hz	125 μ V/V	
	(>150 to 300) V 20 Hz	50 μ V/V	
	(>150 to 300) V 50 Hz to 1 kHz	30 μ V/V	
	(>150 to 300) V 1 kHz to 10 kHz	40 μ V/V	
	(>150 to 300) V 10 kHz to 20 kHz	50 μ V/V	
	(>150 to 300) V 20 kHz to 50 kHz	65 μ V/V	
	(>300 to 500) V 10 Hz	125 μ V/V	
	(>300 to 500) V 20 Hz	50 μ V/V	
	(>300 to 500) V 50 Hz to 1 kHz	35 μ V/V	
	(>300 to 500) V 1 kHz to 10 kHz	60 μ V/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage (Measure) ^[1]	(>300 to 500) V 10 kHz to 20 kHz	90 μ V/V	Holt 6A Thermal Transfer Standard
	(>300 to 500) V 20 kHz to 50 kHz	110 μ V/V	
	(>500 to 1 200) V 10 Hz to 50 kHz	125 μ V/V	
	(>500 to 1 200) V 20 Hz	50 μ V/V	
	(>500 to 1 200) V 50 Hz to 1 kHz	40 μ V/V	
	(>500 to 1 200) V 1 kHz to 10 kHz	60 μ V/V	
	(>500 to 1 200) V 10 kHz to 20 kHz	0.12 mV/V	
	(>500 to 1 200) V 20 kHz to 50 kHz	0.15 mV/V	
AC High Voltage (Source)	(>1 to 5) kV 60 Hz	-0.11 V + 5 V/kV	AR 3605 Hypot Ohm-Labs KV30A Divider Agilent 34411A Multimeter
AC High Voltage (Measure)	(>1 to 5) kV 60 Hz	-0.11V + 5 V/kV	Ohm-Labs KV30A Divider Agilent 34411A Multimeter
AC High Voltage (Measure)	(>5 to 10) kV 60 Hz	1.1 V + 4.7 V/kV	Ohm-Labs KV30A Divider Agilent 34411A Multimeter
	(>10 to 20) kV 60Hz	0.021 kV + 0.004 2 kV/kV	
	(>20 to 60) kV 60Hz	0.018 kV + 0.006 7 kV/kV	Hipotronics KVM 200 Meter, Agilent 34411A Multimeter
DC Voltage Fixed Point (Source)	10 mV	19 μ V/V	Fluke 732A DC Reference Standard 752A Reference Divider
	100 mV	2.6 μ V/V	
	1 V	1.1 μ V/V	
	10 V	1 μ V/V	
DC Voltage Ranges (Source) ^[1]	100 V	1.1 μ V/V	Fluke 732A DC Reference Standard 752A Reference Divider
	1 000 V	1.4 μ V/V	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage Ranges (Source) ^[1]	(0 to <10) μV	9.7 nV + 460 $\mu\text{V/V}$	Keithley 262 Low Thermal Divider Wavetek 4800A Multifunction Calibrator Agilent 3458A Multimeter 1 V Fixed Point
	(10 to <100) μV	3.7 nV + 130 $\mu\text{V/V}$	
	(100 to <1 000) μV	29 nV + 85 $\mu\text{V/V}$	
DC Voltage Ranges (Source) ^[1]	(1 to <10) mV	6 nV + 20 $\mu\text{V/V}$	Keithley 262 Low Thermal Divider Wavetek 4800A Multifunction Calibrator Agilent 3458A Multimeter Keithley 182 Voltmeter 10 V Fixed Point
DC Voltage Ranges (Source) ^[1]	(10 to <100) mV	0.18 nV + 0.34 $\mu\text{V/V}$	Wavetek 4800A Multifunction Calibrator Fluke 752A Reference Divider Agilent 3458A Multimeter 1 V Fixed Point 10 V Fixed Point
	(100 to <1 000) mV	0.14 nV + 0.9 $\mu\text{V/V}$	
DC Voltage Ranges (Source) ^[1]	(1 to <10) V	0.38 μV + 0.99 $\mu\text{V/V}$	Wavetek 4800A Multifunction Calibrator Agilent 3458A Multimeter 1 V Fixed Point 10 V Fixed Point
DC Voltage Ranges (Source) ^[1]	(10 to <100) V	1 μV + 1.1 $\mu\text{V/V}$	Wavetek 4800A Multifunction Calibrator Fluke 752A Reference Divider Agilent 3458 Multimeter 1 V Fixed Point 10 V Fixed Point
	(100 to 1 000) V	-13 μV + 1.4 $\mu\text{V/V}$	
DC High Voltage (Source)	(>1 to 5) kV	-0.037 V + 0.62 mV/V	Extech 7021 Hipot Ohm-Labs KV30A Divider Agilent 34411A Multimeter
DC High Voltage (Source)	(>5 to 10) kV	-3.3 V + 1.3 mV/V	AN/GSM-6B HV Source Ohm-Labs KV30A Divider Agilent 34411A Multimeter

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC High Voltage (Source)	(>10 to 30) kV	-9.4 V + 1.5 mV/V	AN/GSM-6B HV Source Ohm-Labs KV30A Agilent 34411A Multimeter
DC High Voltage (Source)	(>30 to 50) kV	0.034 kV + 5.5 mV/V	AN/GSM-6B HV Source Hipotronics KVM200 Meter Agilent 34411A Multimeter 1 MΩ Shunt
	(>50 to 70) kV	-0.03 kV + 6.8 mV/V	
DC Voltage Fixed Point (Measure)	100 mV 1 V 10 V 100 V 1 000 V	2.6 μV/V 1.1 μV/V 1 μV/V 1.1 μV/V 1.4 μV/V	Fluke 732A DC Reference Standard 752A Reference Divider
DC Voltage Ranges (Measure) ^[1]	(1 to 10) mV	0.18 μV + 9.1 μV/V	Keithley 182 Voltmeter 10 mV Fixed Point
	(10 to 100) mV	0.18 μV + 0.34 μV/V	Agilent 3458A Multimeter 100 mV Fixed Point
DC Voltage Ranges (Measure) ^[1]	(100 to 1 000) mV	0.14 μV + 0.92 μV/V	Wavetek 4800A Multifunction Calibrator Agilent 3458 Multimeter 1 V Fixed Point 10 V Fixed Point Fluke 752A Reference Divider
DC Voltage Ranges (Measure) ^[1]	(1 to 10) V	0.38 μV + 0.99 μV/V	Wavetek 4800A Multifunction Calibrator Agilent 3458 Multimeter 1 V Fixed Point 10 V Fixed Point
DC Voltage Ranges (Measure) ^[1]	(10 to 100) V	1 μV + 1.1 μV/V	Wavetek 4800A Multifunction Calibrator Agilent 3458 Multimeter 1 V Fixed Point 10 V Fixed Point Fluke 752A Reference Divider
	(100 to 1 000) V	-13 μV + 1.4 μV/V	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC High Voltage (Measure)	(>1 to 5) kV	-0.037V + 0.62 mV/V	Extech 7021 Hipot Ohm-Labs KV30A Divider Agilent 34411A Multimeter
	(>5 to 10) kV	-3.3V + 1.3 mV/V	AN/GSM-6B HV Source Ohm-Labs KV30A Divider Agilent 34411A Multimeter
	(>10 to 30) kV	-9.4 V + 1.5 mV/V	
	(>30 to 50) kV	0.34 kV + 5.5 mV/V	AN/GSM-6B HV Source Hipotronics KVM200 Meter Agilent 34411A Multimeter 1 MΩ Shunt
(>50 to 100) kV	-0.049 kV + 7.2 mV/V		
DC Ratio (Source)	(0 to 0.1) ratio	0.28 μV/V + (0.22 μV/V of input X ratio)	Fluke 720A Kelvin Varley Divider
	(0.1 to 1) ratio		
Thermocouple Simulation ^[1]	Type B		Ectron 1140A Thermocouple Simulator
	(250 to 350) °C	1.1 °C	
	(350 to 445) °C	0.86 °C	
	(445 to 580) °C	0.68 °C	
	(580 to 750) °C	0.54 °C	
	(750 to 1 000) °C	0.45 °C	
	(1 000 to 1 820) °C	0.36 °C	
	Type E		
	(-270 to -245) °C	1.4 °C	
(-245 to -195) °C	0.21 °C		
(-195 to -155) °C	0.12 °C		
(-155 to -90) °C	0.097 °C		
(-90 to 15) °C	0.086 °C		
(15 to 890) °C	0.072 °C		
(890 to 1 000) °C	0.086 °C		
Type J			
(-210 to -180) °C	0.14 °C		
(-180 to -120) °C	0.12 °C		
(-120 to -50) °C	0.098 °C		
(-50 to 1 200) °C	0.087 °C		

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thermocouple Simulation ^[1]	Type K (-270 to -255) °C (-255 to -195) °C (-195 to -115) °C (-115 to -55) °C (-55 to 1 000) °C (1 000 to 1 372) °C	2.5 °C 0.81 °C 0.14 °C 0.11 °C 0.089 °C 0.1 °C	Ectron 1140A Thermocouple Simulator
	Type N (-270 to -260) °C (-260 to -200) °C (-200 to -140) °C (-140 to -70) °C (-70 to 25) °C (25 to 160) °C (160 to 1 300) °C	5.8 °C 1.2 °C 0.27 °C 0.18 °C 0.14 °C 0.12 °C 0.11 °C	
	Type R (-50 to -30) °C (-30 to 45) °C (45 to 160) °C (160 to 380) °C (380 to 775) °C (775 to 1 768) °C	0.78 °C 0.67 °C 0.52 °C 0.41 °C 0.38 °C 0.34 °C	
	Type S (-50 to -30) °C (-30 to 0) °C (0 to 250) °C (250 to 1 000) °C (1 000 to 1 400) °C (1 400 to 1 768) °C	0.75 °C 0.68 °C 0.51 °C 0.44 °C 0.4 °C 0.37 °C	
	Type T (-270 to -255) °C (-255 to -240) °C (-240 to -210) °C (-210 to -150) °C (-150 to -40) °C (-40 to 100) °C (100 to 400) °C	2.1 °C 0.57 °C 0.35 °C 0.21 °C 0.14 °C 0.1 °C 0.089 °C	
Oscilloscope Vertical Amplitude DC (1 MΩ)	(0 to 130) V (0 to 6.6) V	29 μV + 0.29 mV/V 46 μV + 0.29 mV/V	Fluke 5800A Oscilloscope Calibrator



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Square Wave (1 MΩ)	1 mV to 130 V pk-pk 10 Hz to 1 kHz	230 μV + 0.59 mV/V pk-pk	Fluke 5800A Oscilloscope Calibrator
	1 mV to 130 V pk-pk (1 to 10) kHz	53 μV + 2.9 mV/V pk-pk	
Square Wave (50 Ω)	1 mV to 6 p 6 V pk-pk 10 Hz to 10 kHz	310 μV + 2.8 mV/V pk-pk	
Pulse Risetime	1 kHz to 10 MHz (200 to 350) ps	120 ps	
Time Mark Source (1-2-5)	2 ns to 20 ms	1.2 μs/s	
	50 ms to 5 s	-32 ns + 3.5 μs/s	
Time Mark Source (non-cardinal)	2 ns to 5 s	58 μs/s	
Leveled Sinewave (Source)	50 kHz to 10 MHz 5 mV to 5.5 V	35 μV + 42 mV/V	
	(10 to 30) MHz 5 mV to 5.5 V	33 μV + 42 mV/V	
	(>30 to 100) MHz 5 mV to 5.5 V	73 μV + 42 mV/V	
	(>100 to 250) MHz 5 mV to 5.5 V	87 μV + 50 mV/V	
	(>250 to 500) MHz 5 mV to 5.5 V	100 μV + 68 mV/V	
	(>500 to 600) MHz 5 mV to 5.5 V	100 μV + 78 mV/V	
	600 MHz to 1 GHz 5 mV to 5.5 V	18 mV/V	
Input Resistance (Measure)	(40 to 60) Ω	7.2 mΩ + 1.1 mΩ/Ω	
	(500 to 1 500) kΩ	17 Ω + 1.2 mΩ/Ω	
Input Capacitance (Measure)	(5 to 50) pF	0.61 pF + 57 mF/F	



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power (Source)	1 mW @ 50 MHz	0.024 mW	HP437A Power Meter
RF Power (Measure)	1 mW @ 50 MHz	0.019 mW	HP 432A Power Meter Agilent 478A Power Meter
RF Power (Absolute Measure)	0.1 nW to 10 μ W (10 to 30) MHz	0.000 003 3 μ W + 0.035 μ W/ μ W	Agilent 437A Power Meter Agilent 8484A Power Sensor
	0.1 nW to 10 μ W (30 to 50) MHz	0.000 003 5 μ W + 0.032 μ W/ μ W	
	0.1 nW to 10 μ W 50 MHz to 2 GHz	0.000 003 5 μ W + 0.032 μ W/ μ W	
RF Power (Absolute Measure)	0.1 nW to 10 μ W (2 to 12.4) GHz	0.000 003 4 μ W + 0.032 μ W/ μ W	Agilent 437A Power Meter Agilent 8484A Power Sensor
	0.1 nW to 10 μ W (12.4 to 18) GHz	0.000 003 3 μ W + 0.034 μ W/ μ W	
	1 μ W to 100 mW 100 kHz to 1 MHz	0.000 037 mW + 37 mW/W	
	1 μ W to 100 mW (1 to 50) MHz	0.000 04 mW + 31 mW/W	
	1 μ W to 100 mW 50 MHz to 2 GHz	0.000 04 mW + 31 mW/W	
	1 μ W to 100 mW (2 to 4.2) GHz	0.000 04 mW + 32 mW/W	
RF Power (Absolute Measure)	(1 to 10) μ W (4 to 10) GHz	0.072 μ W + 0.028 μ W/ μ W	HP 432A Power Meter HP 478A Power Meter
	(10 to 30) μ W (4 to 10) GHz	0.15 μ W + 0.03 μ W/ μ W	
	(30 to 100) μ W (4 to 10) GHz	0.47 μ W + 0.03 μ W/ μ W	
RF Power (Absolute Measure)	(100 to 300) μ W (4 to 10) GHz	1.5 μ W + 0.03 μ W/ μ W	HP 432A Power Meter HP 478A Power Meter
	(0.3 to 1) mW (4 to 10) GHz	0.004 7 mW + 30 mW/W	
	(1 to 3) mW (4 to 10) GHz	0.015 mW + 30 mW/W	
	(3 to 10) mW (4 to 10) GHz	0.044 mW + 30 mW/W	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power (Relative Measure)	0.1 nW to 10 μ W 10 MHz to 18 GHz 1 μ W to 100 mW 100 kHz to 4.2 GHz	0.000 005 2 μ W + 0.006 9 μ W/ μ W 0.000 053 mW + 12 mW/W	Agilent 437A Power Meter, Agilent 8484A Power Sensor

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Cylindrical Pins, Plugs & Thread Wires ^[2]	(0.127 to 101.6) mm (0.005 to 4.0) in	(0.94 + 0.01I) μ m (37 + 10L) μ in	PW LMU 175 Grade 0 Gage Blocks
Inside Micrometers ^[2]	(25.4 to 304.8) mm (1 to 12) in (304.8 to 609.6) mm (12 to 24) in (609.6 to 1 219.2) mm (24 to 48) in	(0.25+ 0.001 7I) μ m (9.8 + 1.6L) μ in (0.63 + 0.002 5I) μ m (25 + 2.5L) μ in (4.3 + 0.00067I) μ m (170 +0.67L) μ in	PW LMU 175
End Measuring Rods ^[2] (Micrometer Standards)	(25.4 to 304.8) mm (1 to 12) in (304.8 to 609.6) mm (12 to 24) in (609.6 to 1 219.2) mm (24 to 48) in	(0.25+ 0.001 7I) μ m (9.8 + 1.6L) μ in (0.63 + 0.002 5I) μ m (25 + 2.5L) μ in (4.3 + 0.00067I) μ m (170 +0.67L) μ in	PW LMU 175
Thickness Gages	(0.025 4 to 1.27) mm (0.001 to 0.05) in	0.54 μ m 21 μ in	PW LMU 175
Steel Rules ^[2]	Up to 1 219.2 mm Up to 48 in	0.19 mm 0.007 5 in	Steel Rule
Gage Blocks ^[2]	(0.203 to 1.27) mm (0.008 to 0.05) in	(0.099 + 0.000 063I) μ m (3.9 + 0.063L) μ in	Comparator Grade 0 Blocks
Gage Blocks ^[2]	(1.27 to 101.6) mm (0.05 to 4.0) in	0.078 μ m + 0.013 μ m/mm 3.1 μ in + 1.3 μ in/in	Comparator Grade 0 Blocks
	(101.6 to 500) mm (4 to 20) in	(0.97 + 0.002 6I) μ m (38 + 2.6L) μ in	Comparator Master Blocks
Plain Ring Gages ^[2]	(1.016 to 3.175) mm (0.04 to 0.125) in (3.175 to 25.4) mm (0.125 to 1) in (25.4 to 355.6) mm (1 to 14) in	0.28 μ m 11 μ in 0.25 μ m 10 μ in (0.22 + 0.25I) μ m (8.7 to 1.87L) μ in	PW LMU 175

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Radius Gages ^[2]	(0.381 to 25.4) mm (0.015 6 to 1) in	0.001 5 mm + 0.035 % of reading 0.000 059 in + 0.035 % of reading	Starrett Vision System
Calipers & Linear Scales ^[1,2]	(0 to 304.8) mm (0 to 12) in (304.8 to 1 524) mm (12 to 60) in	(12 + 0.000 92 <i>l</i>) μm (480 + 0.92 <i>L</i>) μin (15 + 0.001 4 <i>l</i>) μm (590 + 1.4 <i>L</i>) μin	Gage Blocks
Tape Measures ^[2]	Up to 30.48 m Up to 100 ft	(0.031 + 0.000 23 <i>l</i>) mm (0.001 2 + 0.000 23 <i>L</i>) in	Steel Rule
		(0.4 + 0.000 006 6 <i>l</i>) mm (0.016 + 0.000 006 6 <i>L</i>) in	50 ft Tape
Height Gages ^[2]	(0 to 610) mm (0 to 24) in	(23 + 0.01 <i>l</i>) μm (910 + 10 <i>L</i>) μin	Gage Blocks Surface Plate
Height Master & Riser Block ^[2]	(0 to 304.8) mm (0 to 12) in	(7.1 + 0.01 <i>l</i>) μm (280 + 13 <i>L</i>) μin	Gage Blocks
Indicators, Digital, Dial & Test ^[1,2]	(0 to 101.6) mm (0 to 4) in	(2 + 0.004 3 <i>l</i>) μm (79 + 4.3 <i>L</i>) μin	Gage Blocks
Micrometers, Outside, Depth, Bore Gages ^[1,2]	(2.54 to 101.6) mm (0.010 to 4) in	(1.4 + 0.002 4 <i>l</i>) μm (57 + 2.5 <i>L</i>) μin	Gage Blocks
	(101.6 to 508) mm (4 to 24) in	(2.8 + 0.003 7 <i>l</i>) μm (110 + 3.7 <i>L</i>) μin	
Micrometers, High Accuracy ^[1]	(0 to 25.4) mm (0 to 1) in	0.14 μm + 0.003 7 μm/mm 5.5 μin + 3.9 μin/in	Grade 0 Gage Blocks
Thread Micrometer Setting Standard	(1 to 6) in (25 to 150) mm	42 μm 1.1 μm	PW LMU 175
Thread Plugs Pitch Diameter	(0 to 4) in (0 to 101.6) mm	(79 + 1.71 <i>D</i>) μm (2 + 0.001 7 <i>D</i>) μm	PW LMU 175
Thread Plugs Major Diameter	(0 to 4) in (0 to 101.6) mm	(18 + 0.35 <i>D</i>) μm (0.46 + 0.00035 <i>D</i>) μm	
Bubble Levels Level Vial Setting	(50 to 609.6) mm (1.96 to 24) in	4.1 s Vial Setting	Gage Blocks Surface Plate
Bubble Levels Vial Sensitivity	(50 to 609.6) mm (1.96 to 24) in	3.9 s Vial Sensitivity	
Digital Protractors & Inclometers	(0 to 60) °	0.002 °	Gage Blocks Surface Plate Sine Bar
	90 °	0.036 °	Surface Plate Cylindrical Square

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Measuring Microscopes Linear Scale ^[1]	(0 to 101.6) mm (0 to 4 in)	5.1 μm 200 μin	Gage Blocks
Angle	(0 to 90) °	2.6 min	Angle Blocks
Profilometers & Surface Roughness Testers ^[1]	16 Ra 119 Ra	4.1 μin	Roughness Standard
Optical Comparators Linear Scale ^[1]	(0 to 254) mm (0 to 10) in	4.1 μm 160 μin	Gage Blocks
Angular Scales	90 °	36 s	Angle Blocks
Surface Plates ^[1] Overall Flatness	Up to (6 x 6) ft	0.36 μin + 0.85 μin/in	Laser
Surface Plates ^[1] Local Area Flatness (Repeat Reading)	Up to 0.001 in	30 μin	Repeat-o-meter

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Air Speed Velocity (Anemometers, Pitot Tubes)	(1.5 to 30) m/s	0.009 m/s + 1.1 % of reading	Pitot Tube Manometer
Air Flow	(10 to 375) SCFM	0.082 CFM + 0.44 % of reading	Coriolis Flow Meter
Gas Flow (Mass & Volume Flow Meters) ^[1]	(30 to 400) SLPM	0.2 SLPM + 0.27 % of reading	Bell Prover
	(0.1 to 35) SLPM (0 to 100) SCCM	0.002 SLPM + 0.13 % of reading 0.42 SCCM + 0.98 % of reading	Piston Prover
Gas Flow (Balometers, Volume Flow Meters)	(200 to 2 000) SCFM	1.4 SCFM + 0.9 % of reading	Laminar Flow Element
Liquid Flow ^[1]	(1 to 151) L/min	0.002 4 SLPM + 0.22 % of reading	Coriolis Flowmeter
	(0.1 to 60) L/h	0.004 1 L/h + 0.36 % of reading	Time, Weight, Density Correction Applied
Liquid Flow ^[1]	(1 to 226) L/min	0.005 6 SLPM + 0.14 % of reading	Coriolis Flowmeter



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Liquid Flow ^[1]	(39 to 1 556) L/min (0 to 400) gpm	0.12 /min + 0.57 % of reading 0.033 gpm + 0.57 % of reading	Mag Meter
Force - Compression	(9.8 to 4 452) mN (1 to 454) grf (4.44 to 4 440) N (1 to 1 000) lbf	0.018 mN + 0.018 % of reading 0.0019 g + 0.018 % of reading 0.008 2 N + 0.016 % of reading 0.001 8 lbf + 0.016 % of reading	Dead Weight
	(0.91 to 44.48) kN (204 to 10 000) lbf	9.4 N + 0.035 % of reading 2.1 lbf + 0.035 % of reading	10 000 lb 1000 Series Digital Proving Ring
	(2 to 89) kN (460 to 20 000) lbf	15 N + 0.013 % of reading 3 lbf + 0.001 1 % of reading	20 000 lb 1000 Series Digital Proving Ring
Force - Compression	(14.6 to 445) kN (3 284 to 100 000) lbf	69 N + 0.0 02 % of reading 16 lbf + 0.0 02 % of reading	100 000 lb 1000 Series Digital Proving Ring
Force - Tension	(9.8 to 4 452) mN (1 to 454) grf (4.44 to 4 440) N (1 to 1 000) lbf	0.018 mN + 0.018 % of reading 0.001 9 g + 0.018 % of reading 0.007 5 N + 0.02 % of reading 0.001 7 lbf + 0.02 % of reading	Dead Weight
	(0.91 to 44.48) kN (204 to 10 000) lbf	9.4 N + 0.035 % of reading 2.1 lbf + 0.035 % of reading	10 000 lb 1000 Series Digital Proving Ring
	(2 to 89) kN (460 to 20 000) lbf	13 N + 0.001 1 N/N 3 lbf + 0.001 1 lbf/lbf	20 000 lb 1000 Series Digital Proving Ring
	(14.6 to 445) kN (3 284 to 100 000) lbf	26 N + 0.1 1 % of reading 5,9 lbf + 0.1 1 % of reading	100 000 lb 1000 Series Digital Proving Ring
Rockwell Hardness Testers	HRC Low Medium High	0.45 HRC	Indirect Verification per ASTM E18
	HRBW Low Medium High	0.63 HRBW	
	HRA Low Medium High	0.55 HRA	
	HREW Low Medium High	0.44 HREW	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Weights	(0 to 3) g	5.6 μ g + 0.004 4 mg/g	Mettler M3 Balance Class 3 Weights
	(0 to 200) g	0.053 mg + 0.004 7 mg/g	Sartorius ME215S Balance Class 3 Weights
	(0 to 5 000) g	4 mg + 0.002 mg/g	Voland Scale Class 3 Weights
	200 g to 15 kg	9.4 mg + 0.006 1 mg/g	Mettler KA10-3 Comparator Class 3 Weights
Weights	(10 to 50) kg	0.92 mg + 0.007 4 mg/g	Mettler KA50-2/P Comparator Class 3 Weights
Vacuum ^[1]	(0.001 to 10) torr	0.003 7 torr	Capacitance Manometer High Vacuum Pump Diffusion Pump
Pressure-Pneumatic Gage and Absolute Gage Only ^[1]	(18 to 1 000) psia (124 to 6 895) kPa	0.002 3 % of reading	Ruska 2465 Deadweight Tester or Transducers ^[1]
	(0.2 to 18.2) psia (1.37 to 124.1) kPa	0.003 1 % of reading	
Pressure, Hydraulic Gage ^[1]	(1 000 to 15 000) psi (6.894 to 103.42) MPa	0.006 7 % of reading	Ruska 2485 Deadweight Tester or Portable Dead Weight Tester ^[1]
Manometers ^[1]	(0 to 20) inH ₂ O	0.003 inH ₂ O	Meriam Micromanometer
Manometers ^[1]	(0 to 2) inH ₂ O	0.001 5 inH ₂ O 0.04 mmH ₂ O	Dwyer Microtector
Precision Balances (Resolution 0.1 mg) ^[1]	(0 to 205) g	0.35 mg	Standard Mass
Analytical Balances (Resolution 1 mg) ^[1]	(0 to 500) g	0.8 mg	
Analytical Balances (Resolution 10 mg) ^[1]	(0 to 3 200) g	8.1 mg	
Bench Scales (Resolution 0.1 g) ^[1]	(0 to 32) kg	69 mg	
Floor Scales (Resolution 0.2 kg) ^[1]	(0 to 907) kg	0.11 kg	

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque Analyzers	(0.1 to 2 712) N·m (0.1 to 2 000) lbf·ft	0.04 % of reading	Torque Arm Weights
Torque Wrenches ^[1,2]	(0.05 to 5.6) N·m (0.5 to 50) lbf·in (5.6 to 22.6) N·m (50 to 200) lbf·in (20.3 to 135.6) N·m (15 to 100) lbf·ft	(0.001 8 + 0.002 7T) N·m (0.016 + 0.002 7T) lbf·in (0.005 + 0.002 7T) N·m (0.044 + 0.002 7T) lbf·in (0.025 + 0.002 8T) N·m (0.018 + 0.002 8T) lbf·ft	Torque Calibrator
Torque Wrenches ^[1,2]	(135.6 to 2 711.6) N·m (100 to 2 000) lbf·ft	(0.21 + 0.002 8T) N·m (0.15 + 0.002 8T) lbf·ft	Torque Calibrator
Torque Watches ^[1]	(2 to 17) N·m (0.5 to 2.5) ozf·in (8 to 70) N·m (2 to 10) ozf·in	0.1 N·m (0.014 ozf·in) 0.5 N·m (0.071 ozf·in)	Torque Watch Calibrator
Torque Watches ^[1]	(42 to 303) N·m (6 to 43) ozf·in (211 to 1 518) N·m (30 to 215) ozf·in	1.6 N·m (0.22 ozf·in) 6.8 N·m (0.96 ozf·in)	Torque Watch Calibrator
Viscometers	< 10 cP (10 to 100) cP (100 to 1 000) cP (1 000 to 10 000) cP (10 000 to 100 000) cP	0.3 % of reading 0.46 % of reading 0.5 % of reading 0.68 % of reading 0.71 % of reading	Viscosity Standard Thermometer Water Bath
Viscosity Cups	< 10 cSt (10 to 100) cSt (100 to 1 000) cSt	0.98 % of reading 1.7 % of reading 1.7 % of reading	Viscosity Standard Thermometer Water Bath Stop Watch

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Illuminance responsivity (Illuminant A – CIE) White Light Meters	(3 to 2 000) fc (30 to 21 527) lux (100 to 30 000) fL	1.7 % of reading 2.3 % of reading	Radiometer White Light Detector
Spectral Irradiance UV-A (315 to 400) nm Black Light Meters	(100 to 2 000) $\mu\text{W}/\text{cm}^2$	5.8 % of reading	Radiometer Black Light Detector

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Photometric Sources: Correlated Color Temperature: Incandescent, Non-incandescent	(2 300 to 13 000) K	33 K	Spectrophotometer

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Humidity (Source)	(10 to 90) %RH	0.59 % RH + 0.058 % of reading	Thunder 2500 Chamber
Humidity (Measure and Source) ^[1]	(10 to 90) %RH	1.4 %RH	Vaisala HMP37E Humidity Probe, General Eastern C1 Humidity Generator
Infrared Pyrometers	(35 to 50) °C (50 to 100) °C (100 to 350) °C (350 to 500) °C	0.51 °C 0.67 °C 1.7 °C 2.6 °C	Fluke 4181 Calibrator $\epsilon = 0.9$ to 1.0 $\lambda = (8$ to $14) \mu\text{m}$
Temperature Uniformity ^[1] Type J Thermocouple	(-90 to 1 000) °C (-130 to 1 832) °F	1.2 °C + 0.059 % of reading 2.2 °F + 0.059 % of reading	Datalogger w/ External CJC, Thermocouple
	(-90 to 250) °C (-130 to 482) °F	0.25 °C + 0.015 % of reading 0.45 °F + 0.015 % of reading	Datalogger w/RTDs
Temperature Measure ^[1]	(-196 to -100) °C (-321 to -148) °F (-100 to 0) °C (-148 to 32) °F (0 to 660) °C (32 to 1 220) °F	0.04 °C 0.07 °F 0.012 °C + 0.065 % of reading 0.019 °F + 0.065 % of reading 0.012 °C + 0.000 7 % of reading 0.022 °F + 0.000 7 % of reading	Fluke 1594A Super Thermometer Rosemount 162CE SPRT
Temperature Measuring Equipment ^[1]	-196 ± 5 °C -321 ± 9 °F	0.04 °C 0.07 °F	Fluke 1594A Super Thermometer, Rosemount 162CE SPRT, LN2 Dewar
	(-100 to 70) °C (-148 to 158) °F	0.012 °C + 0.006 5 % of reading 0.019 °F + 0.006 5 % of reading	Fluke 1594A Super Thermometer, Rosemount 162CE SPRT, Fluke 7013 Bath, Halocarbon

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Measuring Equipment ^[1]	(60 to 300) °C (140 to 572) °F	0.012 °C + 0.001 1 % of reading 0.022 °F + 0.001 1 % of reading	Fluke 1594A Super Thermometer, Rosemount 162CE SPRT, Fluke 7013 Bath, Silicone Oil
	(150 to 400) °C (302 to 770) °F	0.012 °C + 0.001 1 % of reading 0.022 °F + 0.001 1 % of reading	Fluke 1594A Super Thermometer Rosemount 162CE SPRT Fluke 6045 Salt Bath
ITS 90 – Fixed Point	660 °C 1 220 °F	0.54 °C 0.97 °F	Aluminum Freeze Point Thermocouple Indicator
Surface Temperature Measurement ^[1]	(0 to 250) °C (32 to 482) °F	1.3 °C 2.3 °F	Fluke 741 Process Calibrator Type K Surface Probe

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Time Interval	(0.1 to 5) ns (5 to 50) ns	1 % reading + 15 ps 0.5 % reading + 150 ps	Tektronix 2465 Oscilloscope
	3.3 ns to 10 ¹⁰ s	2.5 x 10 ⁻⁹ Hz / Hz + 500 ps	Fluke PM6681R Counter
Frequency (Measure)	10 Hz to 200 MHz (0.2 to 2) GHz (2 to 26) GHz	2.5 x 10 ⁻⁹ Hz/Hz 2.6 x 10 ⁻⁹ Hz/Hz 6.2 x 10 ⁻⁹ Hz/Hz	Fluke PM6681R Counter
Frequency (Source)	10 Hz to 200 MHz (0.2 to 2) GHz	2.5 x 10 ⁻⁹ Hz/Hz 2.6 x 10 ⁻⁹ Hz/Hz	Signal Generator monitored with Fluke PM6681R Counter
Stop Watches ^[1]	Up to 24 hr	0.058 s/day	Helmut Klein 4500 Timometer
	(1 to 3 600) s	0.12 s	Timer Counter
Tachometers (Contact) ^[1]	(5.76 to 4 189) rad/s (55 to 40 000) rpm	0.21 rad/s + 0.007 % of reading 0.2 rpm + 0.007 % of reading	rpm Standard
Tachometers (Contact) ^[1]	(100 to 1 000) ft/min	0.026 % of reading	rpm Standard Standard Wheel
Tachometers (Non-contact) Strobe & Photo ^[1]	(0.62 to 10 472) rad/s (6 to 100 000) rpm	0.000 4 rad/s + 0.000 6 % of reading 0.003 8 rpm + 0.000 6 % of reading	Function Generator

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rpm (Measure)	(6 to 100 000) rpm	1.2 rpm	Optical Tachometer

DIMENSIONAL MEASUREMENT

1 Dimensional


Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Linear	Up to 304.8 mm Up to 12 in	0.003 6 mm + 0.000 37 % of reading 0.000 14 in + 0.000 37 % of reading	Starrett Vision System
Linear Measurement	(25.4 to 50 800) mm (1 to 2 000) in	450 μm + 0.57 μm/mm 18 μin + 0.57 μin/in	Laser Measuring Machine

2 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angular	(0 to 360) °	0.001 3 ° + 0.000 77 % of reading	Starrett Vision System

Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 ($k=2$), corresponding to a confidence level of approximately 95%.

- Notes:
1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope.
 2. D = diameter in mm, DL = diagonal length in inches, fL = foot lambert, inD = diagonal inches, l = length in mm, L = length in inches, mil = 1/1000 of an inch or 0.001 inch, T = applied torque.
 3. Test currents up to 1000 A are generated using 50 turn coil with no loss of accuracy.
 4. This scope is formatted as part of a single document including Certificate of Accreditation No. L2222



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